

Water Defense, LLC
c/o Scott Smith
Livingston Manor, NY 12758

March 23, 2016

Dear Scott:

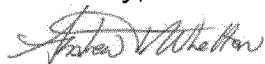
Attached are the results for pipe scale chemical analysis. Our understanding is that the galvanized iron pipe that you provided us originated from a residential potable water plumbing system in Flint, Michigan that was approximately 70 years old, and transported hot water. We received the pipe in a sealed plastic bag and then analyzed it "as-is". This work was conducted by a research associate, graduate student Maryam Salehi, and me.

The results were interesting. You will notice in Table 1 that iron and zinc had very high abundance. This was expected because galvanized iron pipe is known to contain large amounts of both elements. Calcium and magnesium had the next greatest abundance and these elements are ubiquitous in drinking water. Lead was also detected in the pipe scale and its loading was 1,514 $\mu\text{g/g}$. We compared the lead loading to buried water distribution pipe scale analyses reported by others. We were unable to find any chemical analysis data that described Flint Michigan water distribution or building plumbing system pipe scales for comparison. Table 2 shows that lead has been found on the corrosion scales of iron and steel buried water distribution pipes over a wide range: 0 to 98,831 $\mu\text{g/g}$. Although, these data are not directly comparable to small diameter, hot water, and less frequently used building water pipes. Without additional testing of the plumbing system and area, a more complete understanding of lead loadings in plumbing pipe scales cannot be obtained.

The lead detected in the pipe scale could have originated from one or more sources: (1) galvanized iron piping is known to contain trace impurities, and (2) lead could have been released from the corrosion of upstream water pipe network and deposited onto the iron pipe surface.

Please let me know if you have any other questions. I hope that this information is helpful. You can contact me at awhelton@purdue.edu.

Sincerely,



Andrew J. Whelton, Ph.D.

Approach

The pipe scale was digested with acid to determine the amount of heavy metals present on the pipe surface. Pipe scale (1 gram) was mechanically removed and digested in acid using methods previously applied by Lytle et al. (2004). After scale digestion, the liquid was then diluted and analyzed by Inductively Coupled Plasma – Mass Spectrometry (ICP-MS). Analytical standards were used for all 16 elements examined. Results of this work are reported in the enclosed Table 1. Data are reported as the mass of each metal (micrograms) per mass of pipe scale collected (grams). This reporting procedure is how other scientists and engineers have reported pipe scale digestion results from other studies.

Results

Table 1. Element Loading for the Galvanized Iron Pipe Scale

Element	Loading (μg metal /g scale)
Fe	333,625 \pm 41,771
Zn	205,500 \pm 22,293
Ca	13,970 \pm 1,386
Mg	6,765 \pm 544
Al	4,888 \pm 340
Cu	1,952 \pm 155
Pb	1,541 \pm 336
Cd	102.3 \pm 13.8
Mn	43.6 \pm 7.5
Co	41.7 \pm 14.6
Ni	29.6 \pm 7.4
Hg	25.8 \pm 8.8
As	11.0 \pm 0.9
Se	8.1 \pm 1.9
Cr	7.3 \pm 5.5

Mean and standard deviation values shown.
Tables 3 and 4 describe the standards used for each element reported.

Table 2. Comparison of Lead Loading for Flint Galvanized Iron Plumbing Pipe to Lead Loadings Reported for Buried Water Distribution System Pipes

Researchers	Description of Materials	Loading (µg/g)
<i>This Study</i>	<i>1 sample of scale for a premise pipe in Flint Michigan (galvanized iron)</i>	<i>1,541</i>
Yang et al. (2012)	12 samples of scales for water distribution pipes in China (unlined cast iron)	0 to 216; 90th percentile 49
Peng et al. (2012)	58 samples of scales for water distribution pipes in the US (summary of Friedman et al. 2010)	0.84 to 7,200; 90th percentile 850
Lytle et al. (2004)	38 samples of scale for water distribution pipes in the US (cast iron, cement lined, unidentified plastic, PVC)	150 to 98,831
Schock et al. (2008)	91 samples of scales for lead and lead-lined service lines in the US	25,600 to 915,000

This table does not include all available studies.

Table 3. Standards Used for ICP-MS Calibration, µg/L

Element	S1	S2	S3	S4	S5	S6	S7	S8
Al	500	250	100	66.7	50	25	10	5
Cr	500	250	100	66.7	50	25	10	5
Pb	15,000	10,000	5,000	1,000	500	250	50	5
Se	250	125	50	33.3	25	12.5	5	2.5
As	250	125	50	33.3	25	12.5	5	2.5
Co	500	250	100	66.7	50	25	10	5
Mn	500	250	100	66.7	50	25	10	5
V	500	250	100	66.7	50	25	10	5
Be	50	25	10	6.7	5	2.5	1	0.5
Cu	500	250	100	66.7	50	25	10	5
Hg	25	12.5	5	3.4	2.5	1.25	0.5	0.25
Zn	500	250	100	66.7	50	25	10	5
Cd	500	250	100	66.7	50	25	10	5
Fe	250	125	50	33.3	25	12.5	5	2.5
Ni	250	125	50	33.3	25	12.5	5	2.5
Hg	500	250	166.7	100	50	25	-	-

Table 4. Standards Used for ICP-MS Calibration, mg/L

Element	S1	S2	S3	S4	S5	S6
Ca	10	5	3.33	2	1	0.5
Mg	10	5	3.33	2	1	0.5
Na	10	5	3.33	2	1	0.5
Zn	50	25	16.7	10	5	2.5
Fe	50	25	16.7	10	5	2.5

References

- Friedman *et al.* (2010). *Assessment of Inorganics Accumulation in Drinking Water System Scales and Sediments*. Water Research Foundation. Denver, CO USA.
- Lytle *et al.* (2004). Accumulation of arsenic in drinking water distribution systems. *Environ. Sci. Technol.* 38 (20), 5365–5372.
- Peng *et al.* (2012). Occurrence of trace inorganic contaminants in drinking water distribution systems. *JAWWA*. 104 (3), 53–54.
- Schock *et al.* (2008). Occurrence of Contaminant Accumulation in Lead Pipe Scales from Domestic Drinking Water Distribution Systems. *Environ. Sci. Technol.* 42 (12), 4285–4291
- Yang *et al.* (2012). Morphological and physicochemical characteristics of iron corrosion scales formed under different water source histories in a drinking water distribution system. *Water Res.* 46 (16), 5423–5433.